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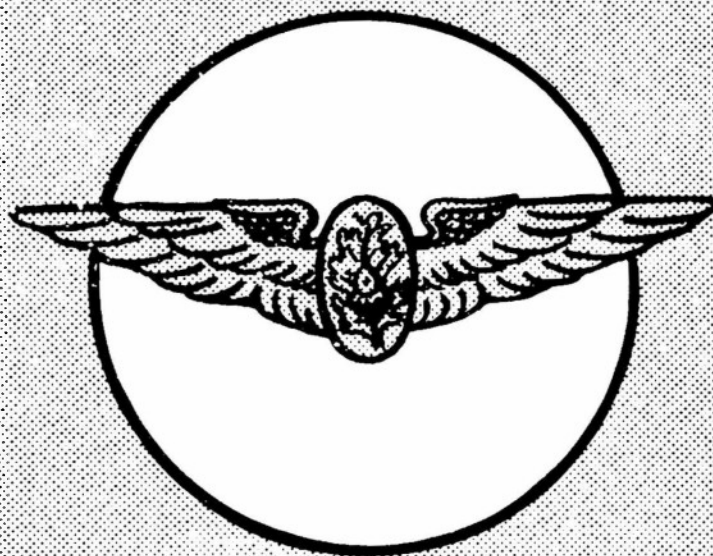
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SIMPLE TEMPERATURE EQUILIBRATION FOR THE  
DETERMINATION OF BLOOD pH

PROJECT NO. NM 001 050.01.10



# RESEARCH REPORT

OF THE

**U. S. NAVAL SCHOOL OF AVIATION MEDICINE**

NAVAL AIR STATION  
PENSACOLA FLORIDA

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JOINT PROJECT REPORT

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SIMPLE TEMPERATURE EQUILIBRATION FOR THE  
DETERMINATION OF BLOOD pH

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## SUMMARY<sup>1</sup>

The temperature-time curves of blood in 10-ml. syringes, cooling from 37°C or warming from 5°C, to room temperature have been studied. When syringes are immersed in water, temperature equilibration between the blood and the environment is practically complete within 5 minutes. Equilibration is relatively slow when syringes stand in air.

The application of these data to temperature equilibration for pH determination with conventional glass electrodes is discussed.

## INTRODUCTION

The pH of human blood drawn anaerobically rises with a fall in temperature (1), and falls with time at a given temperature (2,3). These changes are of sufficient magnitude to necessitate their control, or to require that proper allowance be made for them.

At the present time, despite the theoretical advantages of an electrode maintained at body temperature, most blood pH determinations are carried out with a glass electrode surrounded by air at approximately room temperature. The temperature of the glass electrode is customarily taken as the reading of a thermometer mounted adjacent to the electrode. This temperature is then used to correct the observed blood pH to body temperature with the factor of Rosenthal (1). Accurate determination of blood pH therefore requires that the temperature of the blood sample and the glass electrode be the same.

The present investigations were carried out to determine the time required for this temperature equilibration between blood in a syringe and the environment when the syringe (1) stands in air and (2) is immersed in water at room temperature. Since blood is often chilled after being drawn, when immediate determination of pH is not feasible, these studies were done both on blood cooling after withdrawal from the body and warming following previous refrigeration.

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## METHODS

An iron-constantan thermoelectric junction was soldered to the hub of a B-D needle so that the device could be attached to a Luer-lok syringe. When secured in position on a 10-ml. syringe, the thermoelectric junction projected approximately one inch into the lumen of the syringe. This thermoelectric junction was connected to the input terminals of the U. M. A. skin temperature thermocouple. The instrument was calibrated against an accurate mercury thermometer. Readings were taken visually at intervals of 15 seconds to 1 minute, depending on the rate of change of the temperature.

The experimental procedure was as follows: Six ml. of blood from an afebrile patient was drawn into a 10 ml. B-D syringe, and the thermoelectric junction inserted into the syringe and locked in place. In four experiments the temperature curve was determined with the syringe stationary in room air, while in six experiments it was immersed in a beaker of approximately 600 ml. of water at room temperature. In six other experiments the syringe of blood was refrigerated and then the warm-up temperature curve determined, both in air (3 experiments) and in water (3 experiments). The mean temperatures of the syringe environments in the different groups of experiments were: room air  $24^{\circ}\text{C}$ , water in beaker  $23.3^{\circ}\text{C}$ , refrigerator  $5.7^{\circ}\text{C}$ .

Blood pH was determined with a Cambridge Model R. pH meter equipped with a micro glass electrode. Heparin was used as the anti-coagulant, and no fluoride was added.

## RESULTS

Cooling of the blood in the syringe from body temperature to a stable "equilibrium temperature" occurred at markedly different rates in air and water. The more rapid cooling of the blood with the syringe immersed in water is evident in the experiments shown in Figure 1. Temperature curves in the other experiments in this group were similar. The mean times required for the temperature to reach a value within  $1^{\circ}\text{C}$  and  $0.5^{\circ}\text{C}$  of the final equilibration temperature are given in Table I. It is seen that equilibration to within  $0.5^{\circ}\text{C}$  requires approximately 6 minutes with the syringe in water, less than  $1/4$  the time required in air.

Warming of the blood in the syringe from refrigerator to room temperature required almost 1 hour for equilibration to within  $0.5^{\circ}\text{C}$ , and approximately 3 minutes in water. In one arterial and four venous samples cooling in air, the mean difference between the pH readings at the 5 and 30-minute points was 0.053 pH units.

## DISCUSSION

The more rapid temperature equilibration of the blood when the syringe was immersed in water was due to the higher coefficient of heat transfer across a glass-water interface than across a glass-air interface.

The difference of 0.053 pH units between the 5 and 30-minute readings of blood cooling in air probably represents the error due to introduction of warm blood (5' reading) into a cooler electrode. The 30-minute reading should be correct, since there is negligible fall in pH in this period of time (1). Actually the error due to higher blood temperature would be minimized in the Cambridge electrode, since the glass membrane containing the blood is surrounded by a jacket containing fluid (0.1N HCl). This is not true of all types of anaerobic electrodes for blood work.

It is concluded that the most practical simple method of assuring temperature equilibration between blood and glass electrode is the following:

A. When readings are to be made less than 30 minutes after withdrawal of blood from the body, immerse the capped syringe in water at room temperature for 5 or more minutes.

B. When readings are to be made more than 30 minutes after the sample is drawn, chill the syringe in ice water or refrigerator to minimize glycolysis, then immerse it in water at room temperature for 5 minutes prior to the actual determination.



#### ACKNOWLEDGEMENTS

The technical assistance of Misses Mary Ruth Fordham and Sallie Jones and the work of Miss Mary Elizabeth Upshaw on the chart are gratefully acknowledged.



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2. Harwood, E. R., and Kerridge, T. T.: An immediate acid change in shed blood. Biochem. J. 23:600-607, 1929.
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TABLE I  
MEAN EQUILIBRATION TIMES

Body Temperature to Room Temperature		
	Time to within 1°C of E. T.	Time to within 0.5°C of E. T.
Air	23' 00"	27' 00"
Water	4' 30"	5' 06"
Refrigerator Temperature to Room Temperature		
Air	48' 40"	55' 30"
Water	2' 00"	3' 10"

E. T. = equilibrium (final) temperature

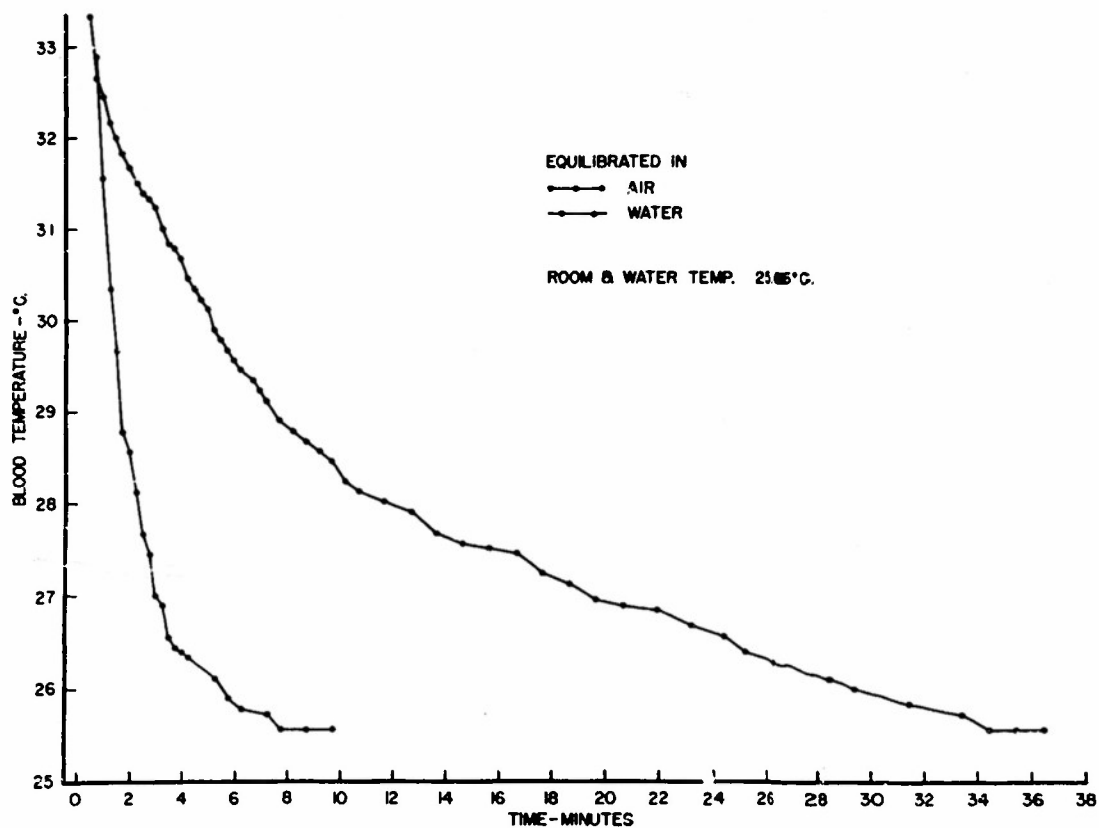


Fig. 1. Temperature-time curves of blood cooling in 10 ml. syringes in air and water.